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MEMC 98-0410 (2489)
PATENT

REMARKS

Applicants submitted Amendment D on October 24, 2003 wherein Applicants amended claims 1 and 13, cancelled claims 23-34 and added new dependent claims 35-62. Review of the Patent Application Information Retrieval System shows no record of previous Amendment D, suggesting that the Amendment was not received by the Office or at least was not joined with the file for the present application. Applicants have attached a copy of Amendment D hereto and request that Amendment D be entered in the present application. Applicants also include a copy of mailing receipt EV 272752654 and check 33426 that accompanied Amendment D as evidence that Amendment D was timely submitted.

In Amendment D, Applicants submitted a listing of claims on pages 2-8 that reflected claims 23-34 as canceled. (See page 5). Further, Amendment D amended claims 1 and 13, while also adding dependent claims 35-62. The remarks beginning on page 9 of Amendment D point to the support for these amendments and additions.

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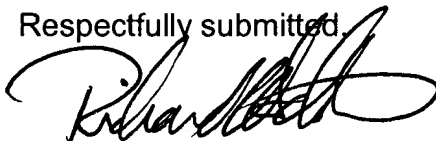
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CONCLUSION

Upon entry of this amendment, claims 23-34 are cancelled. Further, upon entry of this amendment, Applicants respectfully submit that claims 1-22 as amended and new dependent claims 35-62 satisfy the requirements for patentability as stated in Amendment D. Allowance of these claims is therefore respectfully requested.

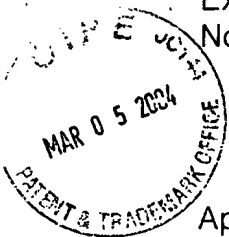
As payment for the added claims was included with Amendment D, Applicants believe that no additional payment is required with this letter. As evidence, a copy of cleared check 33426 has been included to indicate previous payment. Nevertheless, the Commissioner is hereby authorized to charge any underpayment and credit any overpayment of government fees to Deposit Account No. 19-1345.

Respectfully submitted,



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MEMC 98-0410 (2489)
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of Robert J. Falster

Art Unit 2811

Serial No. 09/366,850

Filed August 4, 1999

Confirmation No. 3575

For NON-UNIFORM MINORITY CARRIER LIFETIME DISTRIBUTIONS
IN HIGH PERFORMANCE SILICON POWER DEVICES

Examiner Donghee Kang

October 24, 2003

AMENDMENT D

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In addition to the amendments submitted in Amendment C, filed on September 17, 2003, please amend the above-identified application as follows:

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks/Arguments begin on page 9 of this paper.

EV272752654US

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claim 1 (currently amended) A single crystal silicon segment having two major, generally parallel surfaces, one of which is the front surface of the segment and the other of which is the back surface of the segment, a central plane between the front and back surfaces, a circumferential edge joining the front and back surfaces, a surface layer which comprises a first region of the segment below the front surface and a distance, D_1 , as measured from the front surface and toward the central plane, and a bulk layer which comprises a second region of the segment between the central plane and the first region, the segment being characterized in that

the segment has a non-uniform distribution of minority carrier recombination centers, **the minority carrier recombination centers comprising a substitutional metal**, with the concentration of the centers in the bulk layer being greater than the concentration in the surface layer and with the centers having a concentration profile in which the peak density of the centers is at or near the central plane with the concentration generally decreasing from the position of peak density in the direction of the front surface of the segment and with the concentration generally decreasing from the position of peak density in the direction of the back surface of the segment.

Claim 2 (original) The segment of claim 1 having a carbon concentration which is less than about 1×10^{16} atoms/cm³.

Claim 3 (original) The segment of claim 1 having a carbon concentration which is less than about 5×10^{15} atoms/cm³.

Claim 4 (original) The segment of claim 1 having a thickness ranging from about 500 microns to about 800 microns.

Claim 5 (original) The segment of claim 1 having a thickness ranging from about 800 microns to about 1200 microns.

Claim 6 (previously amended) The segment of claim 1 wherein the concentration of minority carrier recombination centers in the surface layer is less than about 1×10^{11} centers/cm³.

Claim 7 (previously amended) The segment of claim 1 wherein the concentration of minority carrier recombination centers in the surface layer is less than about 1×10^{13} centers/cm³.

Claim 8 (original) The segment of claim 1 wherein the distance D_1 is at least about 10 microns.

Claim 9 (original) The segment of claim 1 wherein the distance D_1 is at least about 30 microns.

Claim 10 (original) The segment of claim 1 wherein the distance D_1 is at least about 50 microns.

Claim 11 (original) The segment of claim 1 wherein the distance D_1 is at least about 100 microns.

Claim 12 (original) The segment of claim 1 wherein the front surface is polished.

Claim 13 (currently amended) A single crystal silicon segment containing minority carrier recombination centers and having two major, generally parallel

surfaces, one of which is the front surface of the segment and the other of which is the back surface of the segment, a central plane between the front and back surfaces, the recombination centers **comprising a substitutional metal and** having a non-uniform distribution between the front and back surfaces with a maximum concentration of the recombination centers being in a region which is between the front surface and the central plane and nearer to the front surface than the central plane and with a minimum concentration of the recombination centers, which is less than the concentration of the recombination centers at the central plane and which is between the front surface and the maximum concentration, the concentration of the recombination centers increasing from the minimum concentration to the maximum concentration and decreasing from the maximum concentration to the central plane.

Claim 14 (original) The segment of claim 13 having a carbon concentration which is less than about 1×10^{16} atoms/cm³.

Claim 15 (original) The segment of claim 13 having a carbon concentration which is less than about 5×10^{15} atoms/cm³.

Claim 16 (original) The segment of claim 13 having a thickness ranging from about 500 microns to about 800 microns.

Claim 17 (original) The segment of claim 13 having a thickness ranging from about 800 microns to about 1200 microns.

Claim 18 (original) The segment of claim 13 wherein the maximum concentration of recombination centers is within about 5 microns from the front surface of the segment.

Claim 19 (original) The segment of claim 13 wherein the maximum concentration of recombination centers is within about 10 microns from the front surface of the segment.

Claim 20 (original) The segment of claim 13 wherein the maximum concentration of recombination centers is within about 20 microns from the front surface of the segment.

Claim 21 (original) The segment of claim 13 wherein the maximum concentration of recombination centers is within about 40 microns from the front surface of the segment.

Claim 22 (original) The segment of claim 13 wherein the front surface is polished.

Claim 23-34 (canceled)

Claim 35 (new) The segment of claim 3, the segment being in the form of a single crystal silicon wafer.

Claim 36 (new) The segment of claim 35, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 37 (new) The segment of claim 3, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 38 (new) The segment of claim 1, the segment being in the form of a single crystal silicon wafer.

Claim 39 (new) The segment of claim 38, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 40 (new) The segment of claim 1, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 41 (new) The segment of claim 1 wherein the substitutional metal is platinum.

Claim 42 (new) The segment of claim 41, the segment having a carbon concentration which is less than about 5×10^{15} atoms/cm³.

Claim 43 (new) The segment of claim 42, the segment being in the form of a single crystal silicon wafer.

Claim 44 (new) The segment of claim 43, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 45 (new) The segment of claim 41, the segment being in the form of a single crystal silicon wafer.

Claim 46 (new) The segment of claim 45, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 47 (new) The segment of claim 41, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 48 (new) The segment of claim 47, the segment having a carbon concentration which is less than about 5×10^{15} atoms/cm³.

Claim 49 (new) The segment of claim 15, the segment being in the form of a single crystal silicon wafer.

Claim 50 (new) The segment of claim 49, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 51 (new) The segment of claim 15, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 52 (new) The segment of claim 13, the segment being in the form of a single crystal silicon wafer.

Claim 53 (new) The segment of claim 52, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 54 (new) The segment of claim 13, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 55 (new) The segment of claim 13 wherein the substitutional metal is platinum.

Claim 56 (new) The segment of claim 55, the segment having a carbon concentration which is less than about 5×10^{15} atoms/cm³.

Claim 57 (new) The segment of claim 56, the segment being in the form of a single crystal silicon wafer.

Claim 58 (new) The segment of claim 57, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 59 (new) The segment of claim 55, the segment being in the form of a single crystal silicon wafer.

Claim 60 (new) The segment of claim 59, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 61 (new) The segment of claim 55, the segment having an asymmetric recombination center profile relative to the central plane of the segment.

Claim 62 (new) The segment of claim 61, the segment having a carbon concentration which is less than about 5×10^{15} atoms/cm³.

REMARKS

A. Status of Claims

Claims 1-34 are pending in the application. Claims 1-22 have been allowed. Claims 23-34 have been canceled. Claims 1 and 13 are currently amended. Support for amended claims 1 and 13 may be found, for example, in the specification at page 8, lines 7-9; page 9, line 20; and page 10, line 1.

Claims 35-62 have been added. Support for claims requiring that the segment be in the form of a single crystal silicon wafer (i.e., claims 35, 38, 43, 45, 49, 52, 57, and 59) may be found, for example, in the specification at page 25, line 20. Support for claims requiring that the segment have an asymmetric recombination center profile relative to the central plane of the segment (i.e., claims 36, 37, 39, 40, 44, 46, 47, 50, 51, 53, 54, 58, 60, and 61) may be found, for example, in the specification at page 24, line 28. Support for claims requiring that the substitutional metal is platinum (i.e., claims 41 and 55) may be found, for example, in the specification at page 11, lines 10-22 and page 16, lines 5-9. Support for claims requiring that the segment have a carbon concentration which is less than about 5×10^{15} atoms/cm³ (i.e., claims 42, 48, 56, and 62) may be found, for example, in the specification at page 12, lines 8-9.

B. Patentability of Amended Claims 1 and 13

As amended, claims 1 and 13 require that the minority carrier recombination centers comprise substitutional metal.

In U.S. Patent No. 5,075,751 (Reference 43 on the IDS filed December 2, 1999), Tomii et al. describe a semiconductor device having an anode zone 12, a cathode zone 13, a high resistance zone 15, and a lattice defect zone 16. The lattice defect zone 16 is positioned such that the peak value Q of the lattice defect distribution is located inside the distribution curve AN of the anode zone 12 and closer to an impurity distribution curve CA of the cathode zone 13. The lattice defect zone 16 acts to shorten the carrier lifetime causing holes injected from the anode zone 12 to disappear quickly. Lattice defect zone 16 is formed by irradiating the device with protons which cause

crystal damage. The damaged crystal, alone, serves as the minority carrier recombination center. In contrast, and among other things, claims 1 and 13 specifically require that the minority carrier recombination centers comprise substitutional metal atoms.

CONCLUSION

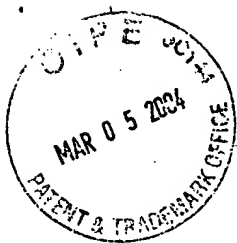
In view of the foregoing, applicants respectfully submit that claims 1-22 as amended and new claims 35-62 satisfy the requirements for patentability. Allowance of these claims is therefore respectfully requested. Enclosed is a check in the amount of \$288.00, representing the difference between the fee for twenty-eight (28) new claims and the twelve (12) canceled claims. The Commissioner is hereby authorized to charge any underpayment and credit any overpayment of government fees to Deposit Account No. 19-1345.

Respectfully submitted;



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Client Name MEMC Electronic Materials, Inc.
Inventor(s) or Mark Robert J. Falster
Serial No. 09/366,850 Patent/Reg. No. _____

The following has been received by the U.S. Patent and Trademark Office on the date stamped hereon:

- ☒ Amendment D
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☐ Brief
☒ Check \$ 288.00
☐ Letter to Commissioner
☐ RCE Transmittal
☐ Maintenance Fee
☐ Section _____ Declaration
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